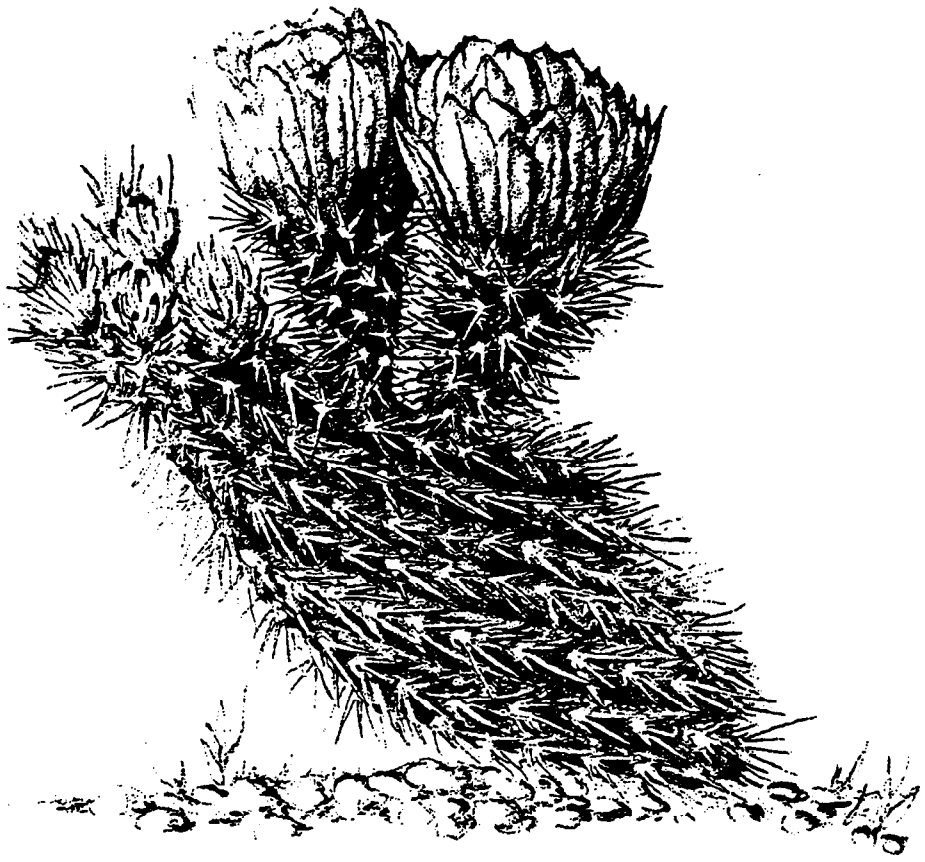
CHISOS MOUNTAIN HEDGEHOG CACTUS

(Echinocereus chisoensis var. chisoensis)

RECOVERY PLAN



U.S. Fish and Wildlife Service
Albuquerque, New Mexico

1993

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(Echinocereus chisoensis var *chisoensis)*

RECOVERY PLAN

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Albuquerque, New Mexico

Approved: _____
Regional Director, U.S. Fish and Wildlife Service

Date: 8 December 1993

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LITERATURE CITATIONS

Literature Citations should read as follows:

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EXECUTIVE SUMMARY FOR CHISOS MOUNTAIN HEDGEHOG CACTUS RECOVERY PLAN

Current Species' Status: ***Echinocereus chisoensis*** var. ***chisoensis*** is federally and state listed as threatened. The variety is an endemic cactus with a very narrow distribution in Brewster Co., Texas. Only 11 small populations are known, all within 30 square miles (19,200 acres) in Big Bend National Park. Less than 1,000 plants are known, and the size and number of populations are believed to be declining.

Habitat Requirements and Limitina Factors: The variety grows on alluvial flats with Chihuahuan Desert Scrub vegetation. Some researchers feel the area was previously arid grassland. The major threat to the variety is illegal collecting. Park development and maintenance activities could also be damaging. Past land management practices and changing climatic conditions may have caused habitat degradation and loss. Habitat needs are not understood and may be limiting recovery. Low population viability may also be limiting recovery.

Recover-v Objective: Delisting.

Recoverv Criteria: Establish 50 distinct populations, each consisting of at least 100 reproductive individuals, and demonstrate that the populations are demographically stable and reproductively successful over a lo-year monitoring period.

Actions Needed:

1. Protect present and newly discovered populations.
2. Establish a reserve germ bank/cultivated population.
3. Conduct biological studies necessary for successful management and restoration.
4. Search for additional populations.
5. Assess restoration feasibility and establish a pilot reintroduction program.
6. Develop a public education program.

Estimated Total Cost of Recovery (Dollars X 1000):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Need 6	Total
1994	17.5	11.0	131.1	16.0	22.5	6.0	204.1
1995	16.8	5.5	120.0	18.0	10.0	3.0	173.3
1996	16.5	3.5	80.0	0.0	10.0	3.0	113.0
1997	16.5	3.5	16.0	0.0	7.5	3.0	46.5
1998	19.5	3.5	16.0	0.0	4.5	3.0	46.5
1999	16.5	1.5	0.0	0.0	4.5	3.0	25.5
2000	16.5	1.5	0.0	0.0	4.5	3.0	25.5
2001	13.5	1.5	0.0	0.0	4.5	3.0	22.5
2002-2009 ea	10.5	1.5	0.0	0.0	0.0	3.0	15.0
TOTAL	227.8	45.0	363.1	34.0	68.0	51.0	791.9

Date of Recovery: If recovery criteria are met, delisting may be possible by 2009.

TABLE OF CONTENTS

I. INTRODUCTION

A. Listina History and Recovery Priority

Echinocereus chisoensis var. ***chfsoensfs*** (Chisos Mountain Hedgehog Cactus, Chisos Pitaya) was federally listed as threatened on September 30, 1988 (U.S. Fish and Wildlife Service 1988b). No critical habitat was designated. ***Echinocereus chisoensis*** var. ***chisoensis*** is also listed as threatened by the State of Texas (Texas Parks and Wildlife Department, Executive Order no. ***88-003,*** December ***30,*** 1988). ***Echinocereus chisoensis*** var. ***chisoensis*** has a recovery priority of 9. Recovery priority numbers for listed species range from 1 to 18, with species ranking 1 having the highest recovery priority. A recovery priority of 9 indicates that this is a variety with a moderate degree of threat and a high recovery potential (U.S. Fish and Wildlife Service 1990).

B. Taxonomy

Echinocereus chisoensis* var. *chisoensis is a small cylindrical cactus (family Cactaceae) with distinctive flowers. It was first collected in 1939, reportedly in the Chisos Mountains of Texas. The locality reported for this initial collection is believed to have been highly generalized, as no populations have ever been found in the mountains. The variety is known only from alluvial flats. It was described as a new species, ***Echinocereus chisoensis*** by W.T. Marshall (1940). Lyman Benson (1969) reduced the **taxon** to a variety **of *Echinocereus reichenbachii.*** The plant was generally known as ***Echinocereus reichenbachii*** var. ***chisoensis*** until the publication of Nigel Taylor's monograph of the genus in 1985. He considered it sufficiently distinct that he returned it to species status and named two varieties, ***Echinocereus chisoensis*** var. ***chisoensis*** endemic to Big Bend National Park, and ***Echinocereus chisoensis*** var. ***fobeanus*** of Coahuila and northeastern Durango, Mexico (also very rare). It should be noted that in the original listing proposal for threatened status (52 FR 25275; July 6, 1987) the nomenclature of Benson was used, but that in the final rule (53 FR 38453; September 30, 1988) the more current nomenclature of Taylor (1985) was followed.

Two spellings of the word **"chisoensis"** have appeared in the literature; **"chisoensis"** is nomenclaturally correct, as.published in Marshall's original description (Marshall 1940). Apparently, in publishing his treatment of the **taxon** as a variety of ***Echinocereus reichenbachii*** Benson (1969) used the spelling **"chisosensis"**, in error. This misspelling was subsequently used in Benson's contributions to floras by Lundell (1969) and Correll and Johnston **(1970),** as well as in Benson's 1982 treatise on cacti. This error in floras and references for cacti has resulted in misspellings in various unpublished reports (Evans 1986, Alex and **Norland** 1987, **Norland** 1987, U.S. Fish and Wildlife Service 1988a).

C. **Morphological Description**

Echinocereus chisoensis var. chisoensis is a relatively low-growing (to 10-12 in., 25-30 cm), cylindrical cactus, reddish-maroon, becoming greener in summer.

The stems are most often singular, though they also form clumps composed of multiple stems with age or injury. The stems have 11-16 vertical or slightly spiraled ribs, which have distinctly separate tubercles separated by broad valleys. The areoles are less than 0.13 in. (3.2 mm) long and about 0.25 in. (6.4 mm) apart, circular and distinctly wooly when young, but becoming elliptic and bare with age.

The spines are relatively sparse and do not completely obscure the stem. The outer (radial) spines number 10-16, and are notably whitish, or ashy to pinkish gray, with brown to maroon tips. The radial spines are slender and irregular in length, the uppermost 0.06-0.13 in. (1.6-3.2 mm) long and bristle-like, the laterals to 0.37 in. (9.5 mm) long and the lowermost to 0.75 in. (19.1 mm) long. The central spines, numbering l-6, are more slender than the radials, and dark brown to black with whitish bases. The largest central spine, 0.63 in. (15.9 mm) long, is the lowermost and is held nearly perpendicular to the stem. The other central spines are 0.25-0.50 in. (6.4-12.7 mm) and spreading.

The flowers are quite distinctive and appear from March to July. They are funnelform, 2.52-3.75 in. (6.4-9.5 cm) long, 0.50 in. (1.3 cm) in diameter, and do not open very widely. The greenish floral tube has a striking woolliness with clusters of bristly or hairy brown-tipped spines. Even more notable are the petals, 2 in. (5.1 cm) long and 0.50 in. (1.3 cm) wide with pointed tips, upright, and having distinctive internal coloration. Internally, the tips of the petals are pinkish to magenta, the throat is white, and the base of the petal is dark crimson. Stamen filaments are white to pink with yellow anthers. The pistil extends about 0.13-0.17 in. (3.2-4.3 mm) above the stamens and has a dark green lo-parted stigma.

The fruits are club-shaped, 1.0-1.4 in. (2.5-3.5 cm) long, and 0.5 in. (1.3 cm) wide. They are greenish-red to red, with white semi-dry flesh, and wooly areoles with bristly or hairlike spines. The fruits split open with age. The seeds are oval, less than 0.06 in. (1.6 mm) in diameter, black, and warty (adapted from Benson 1982, Weniger 1984, Taylor 1985, Evans 1986, and Poole and Riskind 1987).

The stems are'very inconspicuous and the species frequently occurs in the shade and protection of another plant. The best field recognition characters are the distinctive, showy flowers.' When encountered without flowers the best recognition characters

are the reddish-maroon to dark green stem color, ribs with distinct, separate tubercles, contrasting whiteness of the spine mass, brown or maroon tipped outer spines, and cottony wool around the young areoles (Benson 1982, Heil and Anderson 1982a).

D. Distribution and Abundance

Echinocereus chisoensis var. ***chisoensis*** has been recorded only from Brewster County, Texas (Figure 1). Only eleven sites or populations are currently known to exist, and all are located in Big Bend National Park within an area of about 30 square miles. Observers (correspondence from Leuck and **Weedin** included in Heil and Anderson 1982b) note that comparable habitats exist in adjacent areas of Mexico, though the variety has not been found there, and Mexico is not included as part of its known range of distribution. Anderson, Desert Botanical Garden, **(in litt.,** 1993) recently estimated the probable historic range of the species to cover an area up to 150 square miles based on previous reports and probable habitat.

Fewer than 1,000 individuals of ***Echinocereus chisoensis*** var. ***chisoensis*** are known (Heil and Anderson 1982a). A survey by Evans (1986) located only 127 individuals over about 62 miles of transects within the habitat in the Big Bend area. Following a recent reconnaissance trip to the Park, Anderson reported **(in litt.,** 1993) finding only a few dozen plants in visits to known sites. He characterized the plants as being very rare within all of the known sites.

Based on our knowledge of the variety to date it appears that ***Echinocereus chisoensis*** var. ***chisoensis*** has suffered a reduction in its geographical area of distribution and in the size and number of its populations. Many of the populations, especially those accessible to roadways, have been noted to be in decline. Heil and Anderson (1982b) include letters from scientists who had been working with the variety stating that:

> **"Every** time I go to the Park, I find fewer and fewer plants in places where there used to be fairly good populations,..." and . **.."it** looks like some of the same habitat on the Mexican side of the Rio Grande, but I don't know that... (it)... occurs there. If it did I might expect for (sic) cactus poachers (the truckload kind) would have cleaned it out as they have areas west of the **Park"** (correspondence from Leuck, included in Heil-and Anderson 1982b).

> I. ..on the status of the cacti you mentioned. ***E. chisoensis*** is the only one that is losing ground." (correspondence from **Weedin,** included in Heil and Anderson 1982b).

Poole **(1987),** in her field survey of the Big Bend National Park, noted that known populations were declining. Mike Fleming of the National Park Service (pers. **comm.)** has reported losses of small numbers of plants from cactus collecting over the last several years. Anderson (in litt., 1993) following his recent examination, noted that he believes at least two of the

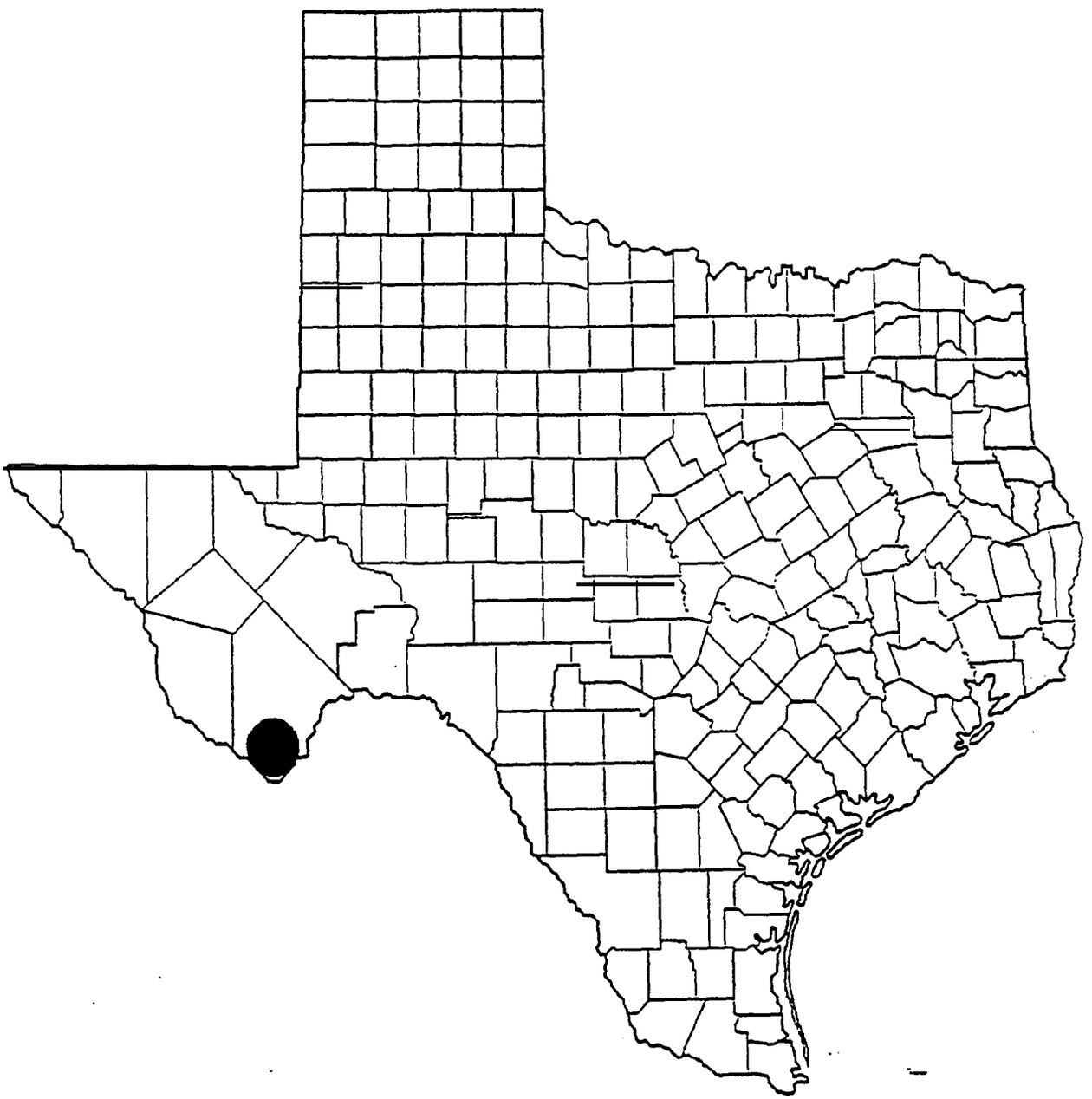

Figure 1.
Distribution of *Echinocereus chisoensis* var. *chisoensis*

populations located in his 1982 survey have decreased in size, probably because of illegal collecting.

Investigators have proposed several reasons for the decline, including illegal collecting, loss of viability in existing populations, and the inability of the present habitat to support reproduction and regeneration (U.S. Fish and Wildlife Service 1988b).

E. Habitat

Echinocereus chisoensis var. ***chisoensis*** occurs in an arid subtropical climate within the Trans-Pecos climatic region of Texas. Climate in this area is extremely variable because of topographic differences. The area generally has great daily temperature fluctuations and an arid profile where evaporation exceeds precipitation (University of Texas at Austin Natural Fibers Information Center 1987). Average annual rainfall is 8-9 in. (20-23 cm), ranging up to 20 in. (51 cm) at high elevations, with the greatest rainfall in August and September. The growing season is 325 days (Heil and Anderson 1982a, 1982b).

This variety is found on alluvial flats. These flats are unconsolidated Quaternary fan and terrace deposits at elevations of 1,950-2,250 ft. (650-750 m) (Heil, Brack, and Porter 1985). The soils are Aridisols eroded to rocky desert pavement (Heil and Anderson 1982a and 1982b). A detailed soil survey for Big Bend National Park was issued in 1985 (U.S. Soil Conservation Service), and surveys of two areas where ***Echinocereus chisoensis*** var. ***chisoensis*** occurs describe the soils as Pantera very gravelly loam and Chamberino very gravelly loam, undulating (Norland 1987, and Alex and Norland 1987). A more detailed description of the soils underlying other populations is needed.

Echinocereus chisoensis var. ***chisoensis*** occurs in areas that are a component of Chihuahuan Desert vegetation classified in Texas as a part of the Trans-Pecos shrub Savannah of Kuchler (1964) and in the Creosote-Lechuguilla Shrub vegetation type of McMahan, Frye, and Brown (1984). The community is likely best placed in the Creosote-Tarbush vegetation series and is characteristic of Chihuahuan Desert flats and eroded former desert grassland communities (Diamond, Riskind, and Orzell 1987). Some investigators speculate that the area may formerly have been a desert grassland that has declined due to overgrazing and/or climatic change (U.S. Fish and Wildlife Service 1988b, Heil and Anderson 1982a, 1982b). Others feel that this is unlikely, though grass cover may once have been much more extensive in the understory than is found today (David Diamond, Texas Parks and Wildlife 'Department, pers. comm., 1990). There is evidence that previous land uses such as overgrazing can result in permanent environmental changes in soils and microclimate that result in long-term vegetation changes (Schlesinger et al. 1990).

F. Associated Species

A detailed quantitative analysis of the plant community in which ***Echinocereus chisoensis*** var. ***chisoensis occurs*** has not been compiled, but Evans (1986) took quantitative measurements of plants immediately associated with the cactus. A qualitative list of associated species was prepared by Poole (1987) and by Heil and Anderson (1982a). Heil and Anderson (1982a) also note that some areas where the variety occurs have only **20-30%** canopy cover. Associated plants include creosote bush **(*Larrea tridentata*)** and lechuguilla **(*Agave lechuguilla*)** as dominant shrubs, with guayacan **(*Guaiacum angustifolia*),** ocotillo **(*Fouquieria splendens*),** yuccas **(*Yucca*** spp.), leatherstem ***(Jatropha dioica),*** mesquite **(*Prosopis glandulosa*),** ceniza ***(Leucophyllum frutescens*),** and white-thorn acacia ***(Acacia constricta)*** also present.

The dominant herbaceous species appears to be dog cholla ***(Opuntia schottii)*** with many other cholla and prickly-pear (0. ***leptocaulis, 0. rufida, 0. violacea, 0. engelmannii)*** and other cacti ***(Echinocereus*** spp., ***Coryphantha*** spp., and ***Echinocactus*** spp.) present. Other herbs listed include hairy erioneuron ***(Erioneuron pilosum),*** range **ratany *(Krameria parviflora),*** and **grama** grasses ***(Bouteloua*** spp.) (Heil and Anderson **1982a,** Poole 1987).

G. Life Historv

Little is known about the phenology or reproductive biology of ***Echinocereus chisoensis*** var. ***chisoensis.*** The status report by Heil and Anderson (1982a) noted that plants may have multiple stems from the same root system, flower from March to June, and fruit from **May to** August. Plants are known to **outcross** readily, but the effective pollinator has not been established (Heil and Anderson 1982a).

Today most plants are found in close association with plants of a variety of other species. These.other plants may be providing needed shelter and acting as **"nurse plants"** (Heil and Anderson **1982a,** U.S. Fish and Wildlife Service **1988b),** though this has not yet been definitively determined.

Seed dispersal mechanisms are unknown.

H. Impacts and Threats

Ecbinocereus chisoensis* var. *chisoensis faces its most immediate threat from illegal collection by commercial and private cacti collectors. With current low numbers of populations and individuals any collection constitutes a severe threat. Big Bend National Park personnel have noted the loss of at least five mature plants in the last 2 years in several incidents of illegal collecting. The latest loss occurred in the spring of 1990 (Mike Fleming, Big Bend National Park, pers. comm., 1993).

Habitat degradation may also be contributing to the decline of the variety. It is believed this area had a much higher cover of grass species in its natural climax condition. Later, with the introduction of grazing between World War I and World War II, the area became eroded and invaded by desert shrubs. The decline of grasses may have destroyed the optimum habitat for ***Ecbinocereus cbisoensis*** var. ***chisoensis*** seedlings, as the variety presently occurs mostly in more sheltered areas and is often associated with a variety of other species that appear to act as "nurse plants" (Heil and Anderson 1982a, U.S. Fish and Wildlife Service 1988b).

Recently, during extended dry periods, Big Bend National Park personnel have noted damage to ***Echinocereus chisoensis*** var. ***chisoensis*** plants from some kind of mammal predation, probably rodents or jackrabbits (Mike Fleming, pers. comm., 1990).

Populations which are located near roadways and interpretive areas of the park could be damaged or destroyed by roadway maintenance and repair work. Future roadway expansion, trail building, or expansion of tourism facilities in the area could also impact some populations. Special attention to this variety's needs will be necessary during the planning and implementation of future facilities and maintenance plans to avoid threatening these populations.

Natural changes in climatic conditions, tending toward a drier regime, may be adversely impacting the reproduction of ***Ecbinocereus chisoensis*** var. ***cbisoensis*** (U.S. Fish and Wildlife Service 1988b).

Echinocereus chisoensis var. ***chisoensis*** is also vulnerable to local catastrophic events (drought, fires, freezes, etc.), which could cause extinction due to the variety's current extremely restricted distribution.

I. Conservation and Research Efforts

The inclusion of known populations of ***Echinocereus chisoensis*** var. ***cbisoensis*** on Federal lands provides for additional assistance to the variety and stronger protective measures under section 7 of the Endangered Species Act of 1973 (as amended). Section 7 (a)(l) directs Federal agencies to **"utilize** their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened **species...".** In addition, under section 7 (a)(2) ***of the*** Act, Federal agencies must evaluate their actions with regard to species proposed or listed as endangered or threatened. Federal agencies are required to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species. If agency activities may have an adverse effect on a species, the agency must enter into consultation with the Fish and Wildlife Service regarding the proposed activities (50 CFR 402).

Big Bend National Park has been active in monitoring and working to conserve the variety. The 1982 Natural Resources Management Plan for Big Bend National Park (National Park Service 1982) recognized the problem of illegal cactus poaching and collecting and stated objectives to address the problem. The National Park Service (NPS) planned to curtail illegal collecting by increased enforcement using patrols in backcountry areas and along roads during heavy use periods. In addition, it planned to enlist public support and to increase understanding with public information and interpretation activities, using exhibits and evening programs and hikes. The National Park Service Resources Management Plan for Big Bend National Park approved in 1988, does not address cactus poaching specifically. It addresses general goals for endangered, threatened, and rare species at the Park. Its goals for endangered species in general include establishing an information base for threatened and category 1 candidate plants, and developing a monitoring system and program for each threatened and category 1 candidate plant. Monitoring planned includes detailed observation on a quarterly basis.

Monitoring projects for ***Ecbinocereus chisoensis*** var. ***cbisoensis were*** initiated in 1987 and are continuing. The NPS has set up two monitoring sites (Alex and **Norland** 1987, **Norland** 1987). Park staff have been observing the plots twice yearly, noting any loss of plants, and recording qualitative observations of phenology, conditions during visual checks, and taking photographs (Mike Fleming, pers. **comm.,** 1990). No specific management plan for ***Ecbinocereus cbisoensis*** var. ***cbisoensis*** has been developed.

Surveys for ***Ecbinocereus cbisoensis*** var. ***cbisoensis*** have been conducted by the Texas Natural Heritage Program (Poole 1987) and the NPS (Evans 1986, Alex and **Norland** 1987, and **Norland**

1987). Field work that has contributed information about the variety's status and distribution has been conducted by Dr. Mike Powell (U.S. Fish and Wildlife Service 1988b), and by Dr. Edward Anderson, Mr. Kenneth Heil, Dr. James Weedin, Dr. Robert Ross, Dr. John Miller, and Dr. Edwin Leuck (Heil and Anderson 1982a, 1982b).

In 1988, prior to the time the species was listed, the National Park Service and Fish and Wildlife Service cooperated in planning to minimize impacts to one population from a planned roadway project in the Park. During the subsequent work, 10 plants from the population were removed from the population. These plants have been cultivated at the Chihuahuan Desert Research Institute.

In cooperation with the NPS, Sul Ross State University and the Chihuahuan Desert Research Institute have experimented with cultivating ***Echinocereus chisoensis*** var. ***chisoensis*** from cuttings and from seed. They have reported success in cultivation from cuttings and now have more than 300 plants, though most are cloned from only a few individuals (Mike Fleming, pers. comm., 1992). This promising cultivation work has shown the potential for establishing a seed bank and cultivated collection. Cultivation efforts need to be expanded to establish a reserve collection of seed (or plants if necessary) that preserves a representative collection of the entire genome. The Center for Plant Conservation (CPC) has also initiated an effort to establish a genetically representative seed reserve with the National Seed Storage Laboratory in Fort Collins, Colorado, and a supporting cultivated collection. The Desert Botanical Garden in Phoenix is implementing this initiative as a member garden of the CPC preservation mission. Collection of material began in 1993. Only a few dozen plants were found, and few had fruit, so initial seed collections were minimal (Anderson, ***in litt.***, 1993).

Lack of information about specific habitat requirements and growth parameters has limited management efforts and progress on recovery activities. Present interpretations of habitat, life history, and population biology are based on the qualitative observations of Heil and Anderson (1982a and 1982b) and Heil, Brack, and Porter (1985).

Some allied research from other areas of investigation have yielded information helpful to recovery planning and activities. Taylor (1985) reports successful propagation of ***Echinocereus chisoensis*** var. ***chisoensis*** from seed or by grafting followed by decapitation of the scion to induce offsetting. The extent of cultivation of ***Ecbinocereus cbisoensis*** var. ***cbisoensis*** by private collectors or commercial producers is unknown, but private propagators may be found to have additional important information about germination and cultivation.

J. Recovery Strategy

Echinocereus chisoensis var. ***chisoensis*** is extremely vulnerable to catastrophic events and illegal collection as only **11** small populations are known, and all are close to one another. Preventing extinction of the species is of first priority. Known populations in Big Bend National Park should be protected from collection and accidental destruction through careful planning, training of park personnel, and law enforcement activities. The Endangered Species Act prohibits collecting or damaging endangered or threatened species on Federal lands.

In addition to physical protection, existing populations should be stabilized and managed to maintain viability. Because so little is known about the variety and its needs, long-term strategic management plans fine-tuned to meet species requirements cannot yet be formulated. Without baseline information to help evaluate responses and guide planning, applying certain management techniques could even prove harmful. An initial site evaluation for each population is recommended. Minimal impact, short-term management guidelines should be developed to preserve sites and deal with any obvious threats until information is collected that will allow long-term, **fine-**tuned strategic management planning and recovery activities. Sites should be carefully monitored for population size and condition.

Because so few individuals are known and the variety is vulnerable to catastrophic destruction, reliance on site management alone is not advised. A seed bank and cultivated collection is recommended to preserve a genetically representative population off-site. This will require studies of seed viability, longevity, germination requirements in cultivation and in the field, and other aspects of seed biology pertinent to a well-managed conservation collection of plants and seed.

Existing populations should be stabilized if necessary. If demographic structure and genetic variability are insufficient to maintain **a** viable, reproducing population, augmentation of the population through pollen manipulation or adding individuals should be considered.

Protection and stabilization alone are insufficient for delisting. Full recovery will require the establishment of additional populations of ***Echinocereus chisoensis*** var. ***chisoensis*** within suitable habitat in the natural, historically likely area of distribution of ***Ecbinocereus chisoensis*** var. ***cbisoensis.*** It does appear that sufficient habitat exists for reintroduction.

Management of existing sites and establishment of new populations will require studies of community composition and

structure, demographic structure, genetic variability and viability, phenology and critically impaired stages of the life cycle, reproductive biology, pollination biology, seed production, seed dispersal, seedling recruitment and biological needs to establish independent plants.

The threat of collection of plants from the wild should be addressed through the monitoring of cactus trade journals, collector's publications, and meetings to prevent illegal trade; through an active education campaign to make field collected plants unacceptable in trade; and by making cultivated material available to satisfy the desire of enthusiasts to own and cultivate the variety.

II. RECOVERY

A. Objective and Recovery Criteria

Objective: The overall, long-term objective of this recovery plan is full recovery of the variety to the point that it can be removed from the Endangered and Threatened Species List.

Criteria: ***Echinocereus chisoensis*** var. ***chisoensis*** will be considered for delisting when 50 distinct populations are established, each population consisting of a minimum of 100 reproductive individuals dispersed over a minimum area of IO-20 acres. In addition, it should be demonstrated that the populations are demographically stable and reproductively successful, as demonstrated by monitoring the species over at least 10 years.

These 50 populations should be distributed across the available habitat in a manner that is designed to minimize losses from catastrophic events. Areas that inherently discourage illegal collection should be given priority in the selection of reintroduction sites. ***Ecbinocereus cbisoensis*** var. ***chisoensis*** is actively sought in the field by knowledgeable collectors, with potentially significant impacts on the demographics and genetic viability of populations subjected to collection. Initial estimates of numbers of populations needed to allow delisting may later be reduced if it can be demonstrated that the demand for field-dug plants is no longer a threat to the variety.

Each population would need to contain enough individuals and genetic variability to assure viability and reproduction. The age-class structure and overall vigor and maturity of the plants must enable the population to survive a variety of conditions (precipitation and temperature extremes, fluctuations in predator and pollinator populations, etc.) and still remain a genetically viable and self-regenerating population. For purposes of establishing initial criteria, the number of individuals and acreage needed was estimated by examining existing population information on the more robust known sites.

A ten-year monitoring period is necessary to demonstrate reproductive success because these plants do not flower until they are 4-6 years old (Heil, **Brack,** and Porter 1985). The ten year monitoring period will also assure that these populations have not been subjected to intolerable collecting pressures.

Presently it is unclear whether the decline of the known populations is due to illegal collection, loss of viability in existing populations, or the inability of the present habitat to support reproduction and regeneration. This need for additional information is addressed in the recovery plan tasks.

These delisting criteria are preliminary. As more information about the variety is accumulated and recovery tasks are accomplished the criteria will be reevaluated and may be revised. The estimated date for attaining the objective of this plan (delisting), if steady progress is made, is 2009.

B. **Recovery** Outline

The following is an outline of the recovery tasks needed to attain the objective of this plan. Section C of this Plan (Narrative Outline of Recovery Actions) includes more detailed information on the tasks.

1. Protect known and newly discovered ***Echinocereus chisoensis*** var. ***chisoensis*** populations from existing and future threats and develop management plans

    11. Protect populations in Big Bend National Park and develop and implement management plans for these populations

        111. Protect sites within the park'

        112. Conduct a site evaluation and develop and implement a short-term management plan for each site

        113. Develop and implement a long-term management plan for each site

        114. Educate National Park Service staff about the presence and importance of ***Echinocereus chisoensis*** var. ***chisoensis***

    12. Monitor populations for general condition, reproductive success, and to identify any needed revisions to the management plans

    13. Evaluate and revise management plans regularly to address changes in the condition of the populations

    14. Ensure compliance with applicable Federal and State laws and regulations

    15. Monitor cactus trade journals and collectors' -publications and meetings

2. Establish a reserve germ bank/cultivated population with responsible agencies/institutions

    21. Include maximum genetic diversity

    22. Establish a monitoring and management plan

    23. Coordinate the cultivation program with research efforts

24. Foster horticultural development of cultivated material to address the commercial demand for horticultural specimens

3. Conduct studies necessary to provide a basis for designing and evaluating protective management and restoration plans

31. Determine exact habitat requirements

311. Determine geologic, edaphic (soil conditions), and hydrologic requirements

3111. Study geology and hydrology

3112. Study soils

312. Study microclimate

313. Study community structure

314. Study community dynamics/ecology

3141. Study the status of the variety in the community

3142. Study the response of ***Echinocereus chisoensis*** var. ***chisoensis*** to disturbance and past land management practices

3143. Study beneficial and negative interactions with other species

3144. Study cyclic and dynamic processes

32. Study population biology

321. Determine present conditions and stability requirements for viable populations

3211. Assess present **demographic conditions,** evaluate demographic requirements for stability, and develop recommendations for any needed augmentation

3212. Assess present genetic viability, evaluate requirements for stability, and develop recommendations for any needed augmentation

322. Characterize phenology and identify the most vulnerable stages of the life cycle

323. Determine reproductive biology and likely causative factors in apparent decline in reproduction in the variety

3231. Determine types of reproduction and contribution to the population

3232. Study pollination biology, including pollen viability

3233. Study seed production, viability and dispersal

3234. Study seedling recruitment

33. Study germination and establishment requirements

331. Study seed biology

332. Study germination requirements

333. Study seedling biology

334. Investigate propagation techniques

4. Search areas with potential habitat for additional populations and potential reintroduction sites

5. Assess restoration feasibility

51. Assess ability of the present habitat to support the species and evaluate the need for habitat restoration

52. Examine reintroduction techniques available

53. Establish a pilot program

54. Assess feasibility of reintroduction program

6. Develop and implement a reintroduction plan, if feasible

7. Develop public concern and support for the preservation and study of ***Echinocereus chisoensis*** var. ***chisoensis***

71. Develop an effective campaign to make the collection or possession of field dug plants of ***Echinocereus chisoensis*** var. ***chisoensis*** unacceptable

72. Educate the public about the vulnerability of ***Echinocereus chisoensis*** var. ***chisoensis,*** the threats that it faces, and recovery efforts

8. Develop a post-recovery monitoring plan.

C. Narrative Outline of Recovery Actions

1. Protect known and newly discovered *Echinocereus chisoensis* var. *chisoensis* populations from existina and future threats and develop manaaement plans. Prospects for the protection of *Echinocereus chisoensis* var. *chisoensis* are excellent. Its occurrence on National Park Service (NPS) land gives the variety the protection of the NPS mandate to protect and preserve its natural features. It also gets the added protection associated with special requirements of Federal agencies under section 7(a)(l) and 7(a)(2) of the Endangered Species Act. Well-planned management actions are needed to ensure the protection of these populations. Because population numbers and sizes are so small, inappropriate land management practices could result in significant loss or damage. Illegal collection is a continuing problem and any collection represents a significant threat to the variety.

   11. Protect populations in Bia Bend National Park and develop and implement manaaement plans for these populations. Management plans should be developed cooperatively between the U.S. Fish and Wildlife Service and the National Park Service. These plans should address short- and long-term needs for protection and management of the populations within the park.

      111. Protect sites within the Dark. Populations of *Echinocereus chisoensis* var. *chisoensis* represent a special natural resource of Big Bend National Park. Immediate steps should be taken by whatever means are appropriate (screening populations from roadside view, physical barriers, reduced access, exclusion of the areas from roadway and tourism development, intensive patrol activities during flowering season, protection from destructive wildlife, staff education, etc.) to protect the variety from known threats. Records and management plans need to be kept strictly confidential with limited access to avoid inadvertantly providing locality information to collectors.

      112. Conduct a site evaluation and develop and implement a short-term manauement Dlan for each site. A simple site description and evaluation should be done for each known population detailing and evaluating its present condition (location, size, substrate, erosion, general plant condition, evidence of predation or disease, history of known collection) and any obvious actions that could be taken to prevent decline (for example, care of damaged plants, protection from roadside view,

protection from predators). Following this evaluation, an interim or short-term management plan should be developed, with practices designed to protect against threats and maintain the populations until comprehensive long-term recovery strategies can be developed. Implementation goals and responsibilities should be clear.

113. Develop and implement a lonu-term manauement plan for each site. The long-term management plan, in addition to providing for protection and maintenance of the populations, should incorporate tasks that will address the need for habitat conservation (including any recommended restoration), preserve population integrity, and ensure population viability and recovery through management and restoration activities. These needs will be determined by research results from quantitative studies recommended in this recovery plan.

114. Educate National Park Service staff about the presence and importance of ***Echinocereus chisoensis*** var. ***chisoensis***. Managers and staff responsible for planning, management, and implementation of projects at the Big Bend National Park should be informed about the plant, its appearance, requirements, and fragility. This should help minimize inadvertent damage and illegal collection. An informed, well-coordinated staff effort, including vegetation maintenance personnel and other work crews, will be needed to preserve the variety.

12. Monitor populations for ueneral condition, reproductive success, and to identify any needed revisions to the manauement plans. During initial research and site management activities the condition of individual populations should be monitored. Monitoring activities -should focus particularly on critical periods such as germination, seedling establishment, the initiation of seasonal growth, bud formation, anthesis, and fruit maturation and dispersal. At least a sample of individuals of all age/size classes should be marked and monitored. Monitoring may be needed less frequently as management needs become clear and population stability improves. Frequent comparisons should be made between populations to help differentiate normal fluctuation from conditions revealing stress or decline. This work was initiated by the NPS in 1987 and should be continued and expanded.

13. Evaluate and revise management plans regularly to address changes in the condition of the populations. As new information becomes available through research and observation it should be incorporated into management strategies. Revisions should be made cooperatively among agencies responsible for conservation planning. If monitoring shows unacceptable decline in the condition of populations, appropriate responses to halt and reverse the situation should be developed cooperatively with all responsible agencies.

14. Ensure compliance with applicable Federal and State laws and regulations. Collecting is one of the main threats to this variety. While this recovery plan attempts to address a long-term approach to removing this threat, in the interim Federal and State laws regarding commercial trade, permits, collecting, and interagency consultation should be enforced.

15. Monitor cactus trade journals and collectors' publications and meetinas. Detection of commercial cultivation, trading activity, and marketplace activity that may be related to illegal collecting may be enhanced by regular checking of journals, newsletters, catalogs, meetings, etc. where "choice" collectable cacti might be discussed or offered for sale. In addition, establishing contacts with persons legally cultivating material may be useful if reintroduction of plants is attempted. These contacts will also assist in attempts to expand the distribution of legally cultivated material to reduce demand for field-collected plants.

2. Establish a reserve *uerm* bank/cultivated population with responsible agencies/institutions. Preservation of ***Echinocereus chisoensis*** var. ***chisoensis*** in its natural environment is absolutely of first priority. However, natural populations appear to be at critically low levels and occur over a restricted geographical area (Heil and Anderson 1982a, 1982b, Poole 1987). To prevent total loss of the variety through some catastrophic event, a seed bank and cultivated population is advised. If initial investigations indicate that seed can be successfully stored, a seed bank would be the most cost-effective way to maintain the genomic reserve. A cultivated collection operating in cooperation with the seed bank program can provide needed support for periodic testing and replenishment operations. Cultivated plants should also serve as a non-destructive source of material for research, restoration, education, and possible horticultural development. It is essential that this cultivation

program proceed responsibly and in a manner that does not threaten the reproductive capacity of existing populations. While promising cultivation work has been initiated with Sul Ross State University and the Chihuahuan Desert Research Institute, this work should be expanded.

21. Include maximum genetic diversity. Reserve materials should be collected and maintained in a manner that will represent and maintain the maximum possible genetic diversity, to preserve the viability of the variety and its ability to respond to natural environmental changes.

22. Establish a monitoring and management plan. Cultivated and reserve material should be periodically monitored and assessed. This program should be guided by a formal management plan. This plan should address such issues as collection guidelines (using similar documentation, maximizing genetic representation, and limiting impacts to wild populations), seed storage, propagation responsibilities and targets, data collection, and distribution and disposal protocol. In addition, the plan should establish cooperation and coordination among all parties, setting limits on annual collection and promoting the sharing of material and data. This coordination among all growers, including commercial producers, should minimize collection pressures and make the best possible use of available material and data collected.

23. Coordinate the cultivation program with research efforts. While ***Echinocereus chisoensis*** var. ***chisoensis*** has been successfully cultivated from seed and offsets by horticulturists and the Chihuahuan Desert Research Institute, little quantitative information on cultivation exists. Cultivation for conservation purposes will require additional investigation and careful documentation. Quantitative research activities relating to cultivation should continue to be supported, both at gardens with conservation collections and through independent researchers examining tissue culture and other techniques. Managers of conservation collections should work in close cooperation with researchers studying reproductive biology, genetics, and restoration needs (sharing cultivation knowledge, contributing research material, and collecting compatible data wherever possible). Field research can help improve cultivation management, and horticultural research can yield important insight into habitat and management needs.

24. Foster horticultural development of cultivated material to address the commercial demand for horticultural specimens. Stocks of certified propagated material should be made available to commercial growers to increase the supply of cultivated specimens for sale. Making cultivated material easily available at reasonable prices should help to meet the demands of cactus collectors and reduce the market for field-collected specimens.

3. Conduct studies necessary to provide a basis for desiuninq and evaluatinu protective manauement and restoration plans. A basic lack of scientific information about the critical parameters of habitat, growth, and reproduction for ***Echinocereus chisoensis*** var. ***chisoensis*** is limiting the ability of conservation agencies to evaluate the limiting factors and to prescribe management activities. Most information available to date is based on qualitative observation; more quantitative research is needed on these and other specific aspects of the life history.

31. Determine exact habitat reuuirements. ***Echinocereus chisoensis*** var. ***chisoensis*** may be in decline due to widespread changes in its habitat that it has been unable to adapt to. These changes might be caused by man's activities, might be natural, or perhaps a combination of the two. Alternatively, present localities might be restricted because of some unique features essential for growth, found only at these sites, that have not yet been identified. Characterization of the habitat where the variety is now growing will help in evaluating the potential for recovery, locating any additional existing populations, and identifying necessary management activities for preservation.

311. Determine ueolouic, edaohic (soil conditions), and hydrolouic reuuirements. The general geologic and topographic profile (flats of unconsolidated alluvial deposits) of this variety-seems well understood (Heil and Anderson 1982a and 1982b), and a soil survey is available for Big Bend National Park (U.S. Soil Conservation Service 1985). Nevertheless a detailed characterization of the geology, soils, and hydrology in the areas where Echinocereus ***chisoensis*** var. ***chisoensis*** occurs should be compiled. These studies may reveal unrecognized patterns or small scale irregularities that need to be taken into consideration in developing management plans. They may also help in locating additional

populations and maintaining cultivated collections.

3111. Study geology and hydrology. A comparative evaluation of the present topography, drainage patterns, and dynamic geological processes of the sites should be made. The study should include an assessment of any alteration in site conditions resulting from past land uses or climatic changes over the last two centuries.

3112. Study soils. Additional, site-specific information is needed about soils, particularly about parameters critical to plant growth such as parent material, texture, porosity, pH, soil water potential, and nutrient levels. A comparative summary and evaluation should be done including all known sites to determine any critical factors.

312. Study microclimate. Characterizing the microclimate of ***Echinocereus chisoensis*** var. ***chisoensis*** plants is essential to understanding management needs of the populations. The tolerance of ***Echinocereus chisoensis*** var. ***chisoensis*** for factors influencing plant stress levels and photosynthesis rates (such as insolation, surface and subsurface temperatures, temperature extremes and profiles, and water availability) should be studied.

Studies are also needed to help answer questions about the spacial arrangement of plants on known sites. The tendency for plants to be found in close association with larger plants ("nurse plants") may be a natural phenomenon resulting from the shelter they offer. Conversely, changes in site character under past land uses (see Schlesinger et al. 1990) may have resulted in a hotter, drier microenvironment that has caused plants to retreat to more sheltered locations. Alternatively, the spacial arrangement may be a secondary result of plants being removed from more open areas by predators and collectors. Conditions found in protected and more open sites should be compared. Identifying local site characters that support the variety is also critical information for reintroduction efforts and successful cultivation programs.

313. Study community structure. Understanding the features, variability, and dynamics of the vegetation in the areas where ***Echinocereus chisoensis*** var. ***chisoensis*** occurs may help in locating additional populations. This information is necessary for planning management of existing sites and evaluating habitat for any future reintroduction efforts. Careful documentation and measurement of all plants present in the habitat through the year may reveal diagnostic features. Documentation of the relative dominance, density, frequency, and constancy is important baseline information necessary for evaluating the status of the area and managing protected sites over time.

314. Study community dynamics/ecology. Information is needed about changes in historical community conditions, their cause(s) and impact on the variety, and about how the community where ***Echinocereus chisoensis*** var. ***chisoensis*** now occurs responds to various management activities and disturbance. Characterization of seasonal events and pressures such as rainfall and temperature regimes and their impact on the variety is needed. The influence of cyclic dynamic processes including drought cycles, flooding events, and fire should be evaluated. Study of positive and negative interactions with other species (herbivory, disease, seed dispersal, and influences on seed bed conditions) is necessary. A knowledge of these processes is important for the formulation of management plans to address maintenance and restoration, as well as for assessment of reintroduction feasibility.

3141. Study the status of the variety in the community. There is some indication that the area where ***Echinocereus chisoensis*** var. ***chisoensis*** now occurs was formerly occupied by a grassland community (Heil and Anderson 1982a, 1982b). Present condition of the vegetation should be investigated to determine if it is a natural mature vegetation, a seral stage, or a new edaphic climax (vegetation controlled by the soil of a site) following disturbance of the natural vegetation and degradation of the original soil. Changes in community composition over the last two centuries should be evaluated in terms of causal factors (grazing and/or climatic change) and potential for restoration. An

evaluation should also be made of the relative position of ***Echinocereus chisoensis*** var. ***chisoensis*** in the existing community and the impact of vegetation changes on the population dynamics of the variety and on its prospects for continued viability.

3142. Study the response of ***Echinocereus chisoensis* var. *chisoensis*** to disturbance and past land management practices. Successful management of the variety will require a knowledge of the plant's responses to various natural events and land use activities. Comparative observation of known populations and analysis of their history of land use, management, and disturbance would be helpful. A comparative study will provide at least preliminary indications of the effects of different disturbances and management practices.

3143. Study beneficial and negative interactions with other species. Some species have an apparent positive interaction with ***Echinocereus chisoensis*** var. ***chisoensis*** such as serving as "nurse plants" for seedlings. Negative impacts from other species such as mammal predation have been reported (Mike Fleming, pers. comm., 1990). Both positive and negative impacts of other species in the community need study. Provisions may need to be made in management plans when certain critical interactions are identified.

3144. Study cyclic and dynamic processes. The correspondence between seasonal cycles (such as rainfall and temperature) and the plant's life cycle or periods of growth and mortality should be investigated to assist in developing management plans. In addition, the impact of more sporadic or cyclical events such as drought, flooding, and fire should be evaluated for historical and future influence on mortality, dispersal, and reproduction.

32. Study population biology. The current status of populations in terms of stability, viability, and reproductive biology (fertility, availability of

pollinators, etc.) are unknown. Studies are needed to evaluate the condition and stability of existing populations and to assist in formulating effective management plans.

321. **Determine present conditions and stability requirements for populations.** The relative stability of known populations in terms of regenerative capacity and genetic diversity is unknown. This information is needed to determine if habitat manipulation or population augmentation such as the addition of plants or pollination manipulation is needed.

3211. Assess Dresent **demographic** conditions. evaluate **demographic requirements** for stability. and **develop** recommendations **for** any needed **augmentation.** Analysis of the distribution of different age-classes in existing populations and the relative contribution of each to regeneration is important in evaluating population persistence and stability (Harper 1977). For populations of ***Echinocereus chisoensis*** var. chisoensis, this information is unknown and needs to be established. The survivorship curve (average number of individuals of a given age class surviving over time) of the variety is not known. This study should provide information needed to assess the demographic stability of populations, and should develop recommendations and targets for numbers of individuals of various ages needed to maintain the population.

3212. Assess Dresent **genetic** viability. evaluate reuuirements for stability, and **develop** recommendations for **any** needed **augmentation**. The genetic viability of ***Echinocereus chisoensis*** var. ***chisoensis*** is unknown. Low variability may develop in areas where populations have few individuals and are geographically isolated from each other (Futuyma 1986). ***Echinocereus chisoensis*** var. ***chisoensis*** populations are fragmented, and remaining individuals are widespread. This can disturb normal pollination processes in outcrossing species and reduce the ability to maintain variability. In addition, many populations consist of 100 or less

individuals, and such low numbers also contribute to the likelihood that genetic drift may have become a threat to recovery.

In some species low genetic variability results in lowered fertility and viability and an impaired ability to respond to environmental change. Other species appear to retain viability even under conditions of low variability. The genetic variability and viability of existing populations of ***Echinocereus chisoensis*** var. ***chisoensis*** needs to be evaluated beginning with simple pollination tests and crossing experiments. If deficiencies are found recommendations for management should be developed.

322. **Characterize phenology and identify the most vulnerable stages of the life cycle.** Irregular observations by botanists are the only indication of seasonal phenology for the variety. A program of taking periodic qualitative **phenological** observations several times during the growing season has been initiated by the NPS in their monitoring plots. These studies should be expanded to include quantitative data collection conducted for several seasons, covering the spectrum ***of*** climatic variation. The resulting data should be compared to climatic data from weather stations located in the park for correspondence. Examination of these data may provide important information about requirements of the variety. An evaluation should be made of any stages in the life cycle that are critical and consistently impaired, any known causes of impairment, and advisable management.

323. **Determine reproductive biology and likely causative factors in apparent decline in reproduction in the variety.** No studies of the reproductive biology of ***Echinocereus chisoensis*** var. ***chisoensis*** are known. This information is needed before management of wild populations, a cultivation program, or restoration and recovery work can be successful. The reproduction of ***Echinocereus chisoensis*** var. ***chisoensis,*** from flowering to the germination and establishment of new plants (including mechanisms, processes, and necessary agents), needs to be understood. Any stages that appear to be impaired should be

evaluated, and recommendations to address these deficiencies should be developed.

3231. Determine types of reproduction and contribution to the population. Seed production through outcrossing and the production of clones have been mentioned as known forms of reproduction (Heil and Anderson 1982a). Additional studies are needed to document the actual incidence of outcrossing and cloning and the potential for other possible breeding scenarios.

3232. Study pollination biology, including pollen viability. The pollinator and pollination biology of ***Echinocereus chisoensis*** **var.** ***chisoensis*** are unknown. A detailed study of insect visitation, pollen development, pollination, pollen predation, pollen viability, and other aspects of pollination biology is needed to determine if failure of any aspect of the pollination system is reducing normal fruit production.

3233. Study seed production, viability, and dispersal. The only existing data on seed production is that provided by Heil, **Brack,** and Porter (1985). Seed production and viability of ***Echinocereus chisoensis*** var. ***chisoensis*** need to be determined, as well as the dispersal mechanism(s) and dispersal distances of seed. Losses of seed crops due to disease and predation should be monitored. This information is needed for cultivation programs, **restoration, and** reintroduction planning.

3234. Study seedling recruitment. The relationship between seed production, seed reserves, and rates of seedling recruitment should be established. Changes in rates of recruitment with different site conditions and optimum conditions for seedling recruitment should also be determined. This information is needed to determine management needs for regenerating populations.

33. **Study germination and establishment requirements.** ***Echinocereus chisoensis*** **var. chisoensis has been** cultivated from seed and induced offsets (Chihuahuan Desert Research Institute 1989, Taylor **1985),** but little

quantitative data exists and additional studies are needed for the establishment of a successful management program for both natural and cultivated populations, as well as for any needed augmentation and reintroduction activity.

331. Study seed biology. Attributes in addition to simple seed production, such as viability, longevity, degree of dormancy, and factors inducing and breaking dormancy need to be determined.

332. Study uermination reauirements. The optimum conditions and range of tolerance for germination under cultivated conditions and in the field (seasonality, soil temperature and moisture, light, etc.) should be established.

333. Study seedlinu biology Light, temperature, moisture, and nutrient'reguirements for seedling establishment (attaining independence from seed reserves and making the transition to independent nutrition and growth) need to be understood. These requirements and tolerance ranges should be investigated under field and cultivated conditions. Threats to seedling establishment (such as disease and predation) need to be identified, monitored, and evaluated.

334. Investiuate propagation techniques. Cultivation from seed and by offsets has been documented (Chihuahuan Desert Research Institute 1989, Taylor 1985). Other propagation techniques, such as tissue culture, should be investigated for use in possible restoration and/or reintroduction efforts. Clonal techniques present challenges in maintaining needed levels of genetic variability. If properly handled however, these techniques may be invaluable for multiplication of selected genotypes to meet restoration or reintroduction program needs. Propagation methods should also be investigated as a means to help meet horticultural demand, because providing readily available propagated plants may reduce collecting threats.

4. Search areas with potential habitat for additional populations and potential reintroduction sites. As more information about the habitat and biology of ***Echinocereus chisoensis*** var. ***chisoensis*** becomes available, predictive abilities for determining areas capable of supporting the variety should improve. Additional surveys should be done for new populations in the U.S. and in Mexico. Potential

reintroduction sites in the U.S. should be noted. Knowledgeable NPS employees working in the area may be helpful in recognizing new populations of the variety.

5. Assess restoration feasibility. An evaluation of the need and potential for reintroduction of the variety can be made when more information is available about the possibility of overlooked populations, genetic vitality, population stability, habitat availability, long-term management requirements of the community, and success of cultivation. In the event that this additional information indicates that reintroduction is feasible and advisable, the following recovery actions (tasks 51-53) should be implemented.

   51. Assess ability of the present habitat to support the variety and evaluate the need for habitat restoration. Based on results of the research examining the condition of present populations and the variety's habitat and regeneration requirements, an evaluation of the suitability of the present habitat to support the variety should be made. The level of restoration or management of sites that will be necessary to recover existing populations in the area should also be determined. Studies (see tasks 312 and 314) may show the area was once grassland or had significantly higher grass cover that was more favorable for the variety than present conditions. If evidence shows that the historic and optimum habitat for Echinocereus chisoensis var. chisoensis had a much higher percent cover of grasses, the possibility for restoration of this more favorable environment should be evaluated and considered as a management objective.

   52. Examine reintroduction techniques available. Evaluate the relative success of different cultivation, site preparation, planting, and management techniques based on past research and monitoring. Assess any additional information needs and readiness to attempt reintroduction. Develop initial reintroduction guidelines.

   53. Establish a pilot program. Using the guidelines developed in task 52, design and implement a pilot program to meet information needs identified in task 52 and test methods.

   54. Assess feasibility of reintroduction program. Assess results of the pilot program, and determine potential for reintroduction as a recovery strategy.

6. Develop and implement a reintroduction plan, if feasible. If reintroduction is determined to be feasible based on the

assessment of the pilot program, a reintroduction plan should be developed and implemented. The reintroduction plan should provide for all phases including plant multiplication, site selection, site preparation, introduction, establishment (to independent living), monitoring, and short- and long-term management strategies.

7. Develop public concern and support for the preservation and study *of Echinocereus chisoensis* var. *chisoensis.* A broad-based awareness of the variety and support for efforts to recover it need to be developed. However, cacti have natural appeal to collectors, and greater awareness is expected to increase demand and therefore increase collection pressures. Public education efforts should proceed only after a provision to meet horticultural demand is in place.

   71. Develop an effective campaign to make the collection or possession of field dua plants of *Echinocereus chisoensis* var. *chisoensis* unacceptable. Horticulturists specializing in cacti, cactus and succulent societies and clubs, native plant societies, and endangered species organizations all have a potential contribution to make in efforts to stop the field collection of cactus plants. Agencies and these groups need to cooperate in developing ways to inform their membership of the vital need to stop the field collection of plants and to enlist their aid and support in eliminating the practice on the part of amateur collectors. They also need to work jointly to develop methods for eliminating illegal (or "black market") commercial markets for field dug plants.

   Service participation with other agencies or groups in a comprehensive campaign to stop the field collection of all cacti would benefit ***Echinocereus chisoensis*** var. ***chisoensis,*** as well as many other rare and listed species and varieties of cacti.

   72. Educate the public about the vulnerability of ***Echinocereus chisoensis*** var. chisoensis,-the threats it now faces, and recovery efforts. The groups mentioned in task 71, park visitors and volunteers, local residents, and the general public need to understand the importance of preserving ***Echinocereus chisoensis*** var. ***chisoensis.*** These groups have an important part to play in encouraging and facilitating the study, preservation, and recovery of the variety. Local and regional appreciation can be furthered through presentations and interpretive materials at Big Bend National Park and local media. Larger audiences are probably best reached through the educational system and youth group curricula, public presentations, and through the use of

print, video and other media products with national or regional distribution.

8. **post-recovery monitoring plan.** If recovery is determined to be feasible, a monitoring plan should be developed that will track the condition of natural and introduced populations for at least 5 years after delisting, as required by the 1988 amendments to the Endangered Species Act. Responsibilities for implementation and reporting should be clear. This plan should specify types and levels of decline that should trigger intervention.

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III. IMPLEMENTATION SCHEDULE

The following implementation schedule outlines actions and estimated costs for recovering ***Echinocereus chisoensis*** var. ***chisoensis.*** It is a guide for meeting the objectives discussed in Part II of this Plan. The schedule indicates task priorities, task numbers, task descriptions, duration of tasks, responsible agencies, and estimated costs. These actions, when accomplished, should bring about the recovery of ***Echinocereus chisoensis*** var. ***chisoensis*** and protect its habitat. It should be noted that the estimated monetary needs for all parties involved in recovery are identified for the first 3 years only, and therefore are not reflective of total recovery costs. The costs estimated are intended to assist in planning. This recovery plan does not obligate any involved agency to expend the estimated funds.

Task Priorities

Priority 1 - An action that must be taken to prevent extinction or to prevent the variety from declining irreversibly in the foreseeable future.

Priority 1• - An action that by itself will not prevent extinction or an irreversible decline, but which is necessary to carry out a task that is a priority 1 as defined above.

Priority 2 - An action that must be taken to prevent a significant decline in the variety's population/habitat quality, or some other significant negative impact short of extinction.

Priority 3 - All other actions necessary to meet the recovery objective.

Abbreviations Used

CPC - Center for Plant Conservation
FWS - Fish and Wildlife Service
  ES - Ecological Services
  LE - Law Enforcement
NPS - National Park Service
scs - Soil Conservation Service
TPWD - Texas Parks and Wildlife Department
MEX - Mexico

CHISOS MOUNTAIN HEDGEHOG CACTUS RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	FY 1	FY 2	FY 3	
1	111	Protect sites within Big Bend National Park	ongoing			NPS	8.0	2.0	2.0	
1	112	Conduct site evaluations and develop and implement short-term management plans	2	2	ES	 NPS TPWD	2.5 2.5 0.8	1.0 1.0 0.3		
1	114	Educate NPS staff about the presence and importance of the variety	2	2	ES	 NPS	2.0 2.0	2.0 2.0		After programelopment, task would be incorporated into standard NPS training.
1	12	Monitor populations	ongoing	2	ES	 NPS TPWD	1.0 4.0 .5	1.0 4.0 .5	1.0 4.0 .5	Necessary to 113, 13, 53, 54, 6 will be useful to tasks 322, 3231, 3233, 333, 313, 3141, 3143
1	14	Ensure compliance with Federal and State laws and regulations	ongoing	2	ES LE	 NPS TPWD	1.0 1.0 1.0 0.5	1.0 1.0 1.0 0.5	1.0 1.0 1.0 0.5	
1	15	Monitor cactus trade journals and collectors' publications and meetings	ongoing and continuous	2	ES LE	 TPWD	1.0 1.0 ... 1.0	1.0 1.0 1.0	1.0 1.0 1.0	
1	21	Establish germ bank/cultivated population with maximum genetic diversity	5	2	ES	CPC NPS TPWD	3.0 5.0 .5	1.5 2.5 .5	0.75 1.3 .5	Necessary to 111, 3212, 3233, 331, 332, 334, 52, 53, and 6.
1	24	Foster horticultural development of cultivated material to address commercial demand	5	2	ES	CPC NPS	 0.5 1.0	 0.5 1.0	 0.5 1.0	

CHISOS MOUNTAIN HEDGEHOG CACTUS RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	FY 1	FY 2	FY 3	
1	71	Develop an effective campaign to make collection or possession of field dug plants of Echinocereus chisoensis var. chisoensis unacceptable	continuous	2	ES	NPS TPWD	5.0 5.0 2.0	5.0 5.0 2.0	5.0 5.0 2.0	Should be closely coordinated with task 24.
1•	3211	Assess present demographic conditions and evaluate requirements for stability	4	2	ES	NPS	1.0 5.0	1.0 5.0	1.0 5.0	Necessary to 113, 2, 3213, 52, 53, 6, and 8.
1•	3212	Assess genetic viability and evaluate requirements for stability	3	2	ES	NPS	1.0 11.0	1.0 11.0	1.0 11.0	Necessary to 113, 21, 52, 53, 6, and 8.
1•	322	Characterize phenology and identify vulnerable stages of life cycle	5	2	ES	NPS	1.0 5.0	1.0 5.0	1.0 5.0	Necessary to 113, 12, 21, 24, 13, 3142, 3143, 51, 52, 53, 6, and 8.
1•	3231	Determine types of reproduction and contribution to population	3	2	ES	NPS	1.0 8.0	1.0 8.0	1.0 8.0	Necessary to 113, 12, 14, 3213, 51, 52, 53, and 6.
1•	3232	Study pollination biology	2	2	ES	NPS	1.0 8.0	1.0 8.0		Necessary to 113, 12, 3213, 51, 52, 53, and 6.
1•	3233	Study seed production, viability, and dispersal	3	2	ES	NPS	1.0 8.0	1.0 8.0	1.0 8.0	Necessary to 113, 12, 24, 3213, 51, 52, 53, and 6.
1•	3234	Study seedling recruitment	5	2	ES	NPS	1.0 8.0	1.0 8.0	1.0 8.0	Necessary to 113, 12, 21, 24, 3213, 51, 52, 53, 6, and 8.
1•	331	Study seed biology	5	2		NPS	2.0	1.0	1.0	Necessary to 21, 24, 51, 52, 53, and 6.
1•	332	Study germination requirements	1	2		NPS	4.0			Necessary to 113, 21, 24, 51, 52, 53, and 6.
1•	333	Study seedling biology	2	2		NPS	2.0	1.0		Necessary to 113, 12, 21, 24, 51, 52, 53, and 6.
2	113	Develop and implement long-term management plans	continuous	2	ES	NPS TPWD			2.5 2.5 1.0	Starts after short-term plan. Necessary to tasks 6 and 8.

CHISOS MOUNTAIN HEDGEHOG CACTUS RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	FY 1	FY 2	FY 3	
2	13	Evaluate and revise management plans regularly	every 2-3 years	2	ES	NPS TPWD				Not needed until years 5 or 6.
2	22	Establish a monitoring and management plan for cultivated and reserve material	1	2	ES	NPS TPWD	0.5 0.5 0.5			Necessary to task 21.
2	23	Coordinate cultivation program with research efforts	ongoing and continuous	2	ES	CPC TPWD NPS	0.5 0.5 0.5	0.5 0.5 0.5	0.5 0.5	Necessary to tasks 21, 53, and 6. Helpful to tasks 3213, 3232, 3233, 331, 333, and 334.
2	3111	Study geology and hydrology	2	2	ES	NPS	1.0 8.0	1.0 8.0		Necessary to 113, 4, 53, and 6.
2	3112	Study soils	1	2	ES	NPS SCS	.5 5.5 1.8			Necessary to 113, 4, 53, and 6.
2	312	Study microclimate	2	2	ES	NPS	1.0 8.0	1.0 8.0		Necessary to 113, 4, 53, and 6.
2	313	Study community structure	2	2	ES	NPS	1.0 11.0	1.0 11.0		Necessary to 113, 4, 52, and 6.
2	3141	Study the status of the variety in the community	3	2	ES	NPS	1.0 8.0	1.0 8.0	1.0 8.0	Necessary to 113, 51, 52, and 6.
2	3142	Study the response to disturbance and past land management practices	5	2	ES	NPS	1.0 5.0	1.0 5.0	1.0 5.0	Necessary to 113, 4, 51, 52, and 6.
2	3143	Study interactions with other species	3	2	ES	NPS	1.0 8.0	1.0 8.0	1.0 8.0	Necessary to 113, 51, 52, and 6.
2	3144	Study cyclic and dynamic processes	2	2	ES	NPS	0.5 1.5	0.5 1.5		Necessary to 113, helpful to 51,52, and 6.

CHISOS MOUNTAIN HEDGEHOG CACTUS RECOVERY PLAN IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (YRS)	RESPONSIBLE PARTY			COST ESTIMATES ($000)			COMMENTS
				FWS						
				REGION	PROGRAM	OTHER	FY 1	FY 2	FY 3	
2	334	Investigate propagation techniques	3	2	ES	NPS	0.5 3.5	0.5 3.5	0.5 3.5	Necessary to tasks 24, 52, 53, and 6.
2	4	Search areas with potential habitat for additional populations and potential reintroduction sites	2	2	ES	MEX NPS TPWD	2.5 .. 2.0 1.5	2.5 .. 2.0 1.5		Necessary to tasks 51, 53, and 6.
2	51	Assess ability of the present habitat to support the variety and evaluate the need for habitat restoration	3	2	ES	NPS TPWD	1.5 1.0 0.5	1.5 1.0 0.5	1.5 1.0 0.5	Depends on outcome of task 3.
3	52	Examine reintroduction techniques available	1	2	ES	NPS TPWD	1.5 2.0 0.5			Needed for tasks 53 and 6.
3	53	Establish pilot program for reintroduction	3	2	ES	NPS TPWD	1.0 7.0 0.5	0.5 2.0	0.5 2.0	Needed for task 6.
3	54	Assess feasibility of reintroduction program	1	2	ES	NPS TPWD				Follows completion of task 53.
3	6	Develop and implement a reintroduction plan, if feasible	8	2	ES	NPS TPWD				Depends on outcome of task 5.
3	72	Educate the public about Echinocereus chisoensis var. chisoensis	ongoing and continuous	2	ES	NPS TPWD	3.0 2.0 1.0	1.0 1.0 1.0	1.0 1.0 1.0	
3	8	Develop a post-recovery monitoring plan	2	2	ES	TPWD NPS				

IV. APPENDIX

Summary of Comments Received on the Draft Chisos Mountain Hedgehog Cactus Recovery Plan

This recovery plan was sent out for technical review to the advisors on the Texas Plant Recovery Team in 1992. No substantive changes were recommended. In April and May of 1993 the Service distributed 67 copies of the draft recovery plan to agencies, academic researchers, cacti growers and associations, international officials, conservation organizations, agricultural producer organizations, and interested individuals. In addition, 15 letters were distributed notifying addressees that the plan was available for public review and comment. Comments were received from the 11 respondents listed below.

Dr. Edward F. Anderson, Senior Research Biologist, Desert Botanical Garden, Phoenix AZ
Dr. Exequiel Ezcurra, Instituto **Nacional** de **Ecologia,** Mexico
Gena Janssen and Jackie Poole, Texas Parks and Wildlife Department
Dr. Kent E. Holsinger, Department of Ecology and Evolutionary Biology, The University of Connecticut
Dr. Nigel Taylor, Royal Botanic Gardens, Kew, England
The Texas Department of Agriculture
United States and Mexico International Boundary and Water Commission
U.S. Department of the Interior, National Park Service, Big Bend National Park
University of Texas at Austin Chapter, the Society for Conservation Biology (Ray Emmett, Jim Leebens-Mack, Leland Russell, and David **Zippin**)
Dr. Jim **Weedin,** Division of Science, Community College of Aurora
Dr. Michael J. **Warnock,** Department of Biological Sciences, Sam Houston State University

All comments were considered when revising the draft plan. The Service appreciates the time that each of the commenters took to review the draft and to submit their comments.

Most of the letters were supportive of the plan, and a number of positive comments were made regarding comprehensiveness, logic, general approach, and organization. Several commenters liked the idea of a short-term and a long-term management plan, and several were enthusiastic about provisions to address illegal collecting, particularly by supporting the development of sources of legally propagated plants. There was

support for establishing a conservation collection and for emphasizing the integration of the conservation collection effort with other research endeavors.

The critical comments and suggestions discussed below represent a composite of those received. Comments of a similar nature are grouped together. Substantive comments that question approach, methodology, or financial needs called for in the draft **plan,** or suggest changes to the plan, are discussed here. Comments received that related to the original listing decision or general comments about the Endangered Species Act that did not relate to the Chisos Mountain hedgehog cactus are not discussed here. Comments regarding simple editorial suggestions, such as better wording or spelling and punctuation changes, were incorporated as appropriate without discussion here.

All comments received are retained as a part of the Administrative Record of recovery plan development in the Austin, Texas Ecological Services office.

Comments Concerning Illegal Collection

Comment: Use of the word overcollecting to describe the threat from poaching of plants in the Park is too mild a term. These plants are so sparsely distributed now and have been so impacted by collecting over the years that ANY collecting of this variety is a severe threat.

Service Response: We agree and have changed the text accordingly.

Comment: Reducing poaching will hinge largely on education efforts. Given that many rare cacti are present in West Texas, a comprehensive cactus education program might be able to meet the recovery goals of many species at once.

Service response: Most cacti species would benefit from a campaign to make the purchase or possession of field-dug plants unacceptable. The Service agrees that more general education programs directed at poachers and their clients may be helpful in reducing this threat, and did not intend to appear to exclude such comprehensive educational endeavors. We have included language under task 7 to make it more clear that projects aimed at changing this destructive activity in general could help this variety. Educational activities that are more specifically oriented to Chisos Mountain hedgehog cactus may also be necessary and appropriate.

Comment: More emphasis should be place on alternatives to poaching. An efficient cultivation program will be needed to provide specimens for collectors.

Service response: The recovery plan provides for establishing a cultivation mechanism expressly for this purpose. This is covered primarily in task 24, but the plan also integrates the concept into tasks 2, 22, and 7.

Comments About Fiscal and Administrative Concerns

Comment: An explicit plan is needed to evaluate research proposals and ensure that information is gathered properly and data collected will actually answer the questions posed. Perhaps a rotating committee should be established.

Service response: The Service has internal proposal review and report approval processes for Service funded activities and for activities requiring scientific permits. These reviews are conducted by the Service's professional endangered species staff, with assistance from the Texas Plant Recovery Team or outside authorities on an as-needed basis. The Service does not feel that review processes need to be addressed in recovery plans. It should be noted that recovery research activity (including the evaluation of proposals and quality control for work in progress) does not reside solely with the Service. Many individuals, agencies and institutions fund and/or conduct research relating to the recovery of listed species. Existing mechanisms of research proposal review by funding agencies operate to ensure those agencies' goals are met.

Comment: This recovery plan requests greater funding than other similar cactus recovery plans. How can you justify such a large budget, especially given that this **taxa** is a variety and not a full species?

and

Comment: A first year budget need of $215,800 seems high in light of real world available dollars and the realignment of the Department of the Interior's research staff and budget components.

Service Response: It should be noted that the summary of projected funding needs in recovery plans represents the Service's best estimate of what would be required to achieve full recovery and allow delisting of the species. Plans are specific for a given species and situation. This cactus is extremely vulnerable and factors impacting the potential recovery are very complex. Addressing these factors will require a diversity of studies, and it is believed that full recovery will require intense effort.

Recovery plans are planning documents. They are intended to provide a **roadmap** of the magnitude and scope of tasks necessary

to achieve a particular goal, full recovery of the listed entity. The recovery plan is not a budget request, nor does it obligate the Service or any other agency or cooperator to expend funds in the recovery of the **taxa** concerned. It is anticipated that the plan would assist agencies and institutions in preparing budgets and grant proposals, and seeking needed funds. The plan does not impose or imply any judgement on funding of recovery of this variety vs. any other listed **taxon,** whether full species or varieties. Relative priority for the expenditure of funds and labor is established with the assignment of recovery priority numbers to species and tasks. Funding is not allocated on a plan-by-plan basis. Funding is allocated based on species priorities and task priorities across all listed **taxa.** Few species have yet received all the funding necessary for full recovery.

It is unclear which other cacti plans are referred to. Plans approved prior to implementation of the 1988 amendments to the Endangered Species Act showed only costs estimated to be incurred by the Service directly in the recovery process. New plans since 1988 attempt to provide a more comprehensive estimate including the potential costs of other cooperators or agencies.

Comment: It is apparent that necessary funding and staff for the anticipated recovery needs may be difficult or impossible to obtain in the foreseeable future. Various research aspects mentioned in the recovery plan would be excellent topics for upper-division undergraduate studies and masters theses. In addition scientists from Sul Ross State University and the Chihuahuan Desert Research Institute, as well as staff of the National Park Service, could effectively perform research at minimal costs.

Service response: The Service agrees. Opportunities for partnerships in research and recovery activities through the involvement of University staff and graduate students and the efforts of research institutes has traditionally been one of the most successful and cost-effective means of conducting research for recovery of listed species. As mentioned in the plan (pg. **13),** the involvement of Sul Ross State University and the Chihuahuan Desert Research Institute in working with the National Park Service to cultivate ***Echinocereus chisoensis var. chisoensis*** has already contributed significantly to our knowledge and experience. The cooperative program between the Service and the Texas Parks and Wildlife Department provided for under Section 6 of the Endangered Species Act funds many studies by University scientists and their students, as well as other research scientists. We hope to be able to continue to conduct cooperative studies such as these to benefit this variety.

Comments on the Plan Background Sections

Comment: The description of the locality for the original collection must have been highly generalized or incorrect if it said the collection was from the Chisos Mountains, as the cacti is not found there, but on alluvial flats.

Service response: This is correct. The original locality description is believed to have been highly generalized. The text about the original collection has been modified to clarify this point.

Comment: The Recovery Plan should have a more thorough literature review. If little information is known about this variety there should be a summary of recent cactus ecology literature outlining how current studies on the ecology of other species and genera might relate to this variety.

Service response: The recovery plan discusses all known literature for this variety, including unpublished internal reports, personal interviews, etc. The Service's "Policy and Guidelines for Planning and Coordinating Recovery of Endangered and Threatened Species, May 1990" (Recovery Plan Guidelines) state that a recovery plan is intended to briefly acquaint the reader with what is known about the species, its status, and the threats it faces. While the plan is intended to cover what is known about major aspects of the species' biology, authors are directed that no topic should be covered in tremendous depth and that the introduction is not intended to be a dissertation on the species. It is beyond the scope and purpose of the document to present a comprehensive literature review of broad topic areas, though the authors' incorporate this type of knowledge in task delineation and other aspects of the plan.

Comment: The plan mentions monitoring efforts underway at Big Bend National Park. Are data available now to shed light on the questions posed in the plan?

Service response: As noted in the plan, information gathered to date is qualitative, not quantitative, and has consisted of visual checks and photographic documentation. We have clarified this in the text of the plan. No evaluations have been completed. The plan recommends that this program be expanded to include quantitative data gathering.

Comment: What is the distance between populations? This could have potentially important consequences for population vulnerability to catastrophe. How far are these populations from roads? This could influence vulnerability to poaching.

Service response: As noted on page 5 of the draft plan, all eleven sites are located within an area of about 30 square miles,

and some populations are accessible to roadways. It was not felt to be necessary to reveal specific distances among all populations in the plan. These distances are not listed, nor are the number of populations visible from roadways, as this could aggravate collection problems by providing too much detail to knowledgeable collectors. Recovery criteria note that site selection criteria for restoration or reintroduction work should minimize susceptibility to collection.

Comments on Recovery Criteria

Comment: It is important to clearly define what you mean by population. Recovery (and presumably delisting) will depend on numbers of individuals and numbers of populations and a clear definition of population will ensure a decision based on the intent of the plan and not someone's convenient definition of a population.

Service response: For purposes of the initial recovery criteria, the recovery criteria section of the plan (draft page 22 and 23) states that a population will consist of a minimum of 100 REPRODUCTIVE individuals dispersed over a minimum area of **10-20** acres. This group of individuals must further have persisted for 10 years as a reproductively successful and demographically stable entity.

Comment: Your recovery criteria should be expanded and better justified. Why 50 populations? The criteria should be more flexible. Populations of over 1000 individuals may be more important to survival than smaller populations. It may be critical to have one or two large populations if this variety operates as a large metapopulation.

and

Comment: It may be more realistic and manageable to try to set up a few smaller populations rather than trying to get 5000 plus plants in populations of 100, given current funding constraints.

Service **response:** Recovery criteria are set up to give some measurable goals to the recovery effort. The plan clearly states that the criteria are preliminary and are expected to be revised as more concrete, critical information becomes available. With so little supporting data it is more informative to discuss the objectives of the criteria given rather than the exact derivation of the target numbers.

The objective in setting these criteria has been to maintain demographically stable and viable populations and address the poaching threat and the potential for loss through catastrophic disturbances. The number of populations, as noted in the plan, was set at 50 to give a comfortable margin (above the existing,

apparently unstable situation of 11 sites) of security considering that all poaching or catastrophes can not be prevented.

The number of individuals and land area needed were based on best available natural population profiles on apparently robust sites where qualitative observations have been made for some time. This statement has been added to the text.

There is not yet any solid information about population profiles or dynamics that would support any major deviation from observed numbers either to the much larger or much smaller numbers suggested by commenters. As this critical information becomes available, the criteria for these parameters may be revised.

Comment: The plan should incorporate larger areas of protection than that given for population areas under the recovery criteria. Some cacti are "fugitive" species that do not persist in any given area for very long, but "move" through areas in response to local conditions. If this were the case with this variety it would be wise to include larger areas to incorporate more potential habitat.

Service response: Some populations of this variety are known to have persisted for some time in the Park. Definitive minimal area information is not yet available, and there is as yet no evidence that this variety has a fugitive species profile and requires additional area. If this is later found to be the case the criteria will be revised to reflect this need.

Comments on Tasks and Priorities

Comment: Task 31, Determining habitat requirements, should be a higher priority. Detailed monitoring of existing populations for germination and seedling growth is extremely important.

Service response: In accordance with Recovery Plan Guidelines, assignment of priority numbers to plan tasks is governed by the criteria outlined on page 40. Task 31, because it deals with information needed to maintain overall site quality in terms of longer-term management or survey needs, did not have the component of immediacy for the prevention of imminent extinction that is required to assign a priority 1 or 1• rating. This does not diminish the importance of the task in providing baseline information and assisting in refining research questions necessary to protect and recover the species in the long-term. In response to the concern about monitoring, please note that there is a separate task in the plan, task 12, that provides for monitoring of populations including reproductive success. This task, which is necessary to determine if a population is in decline and to what degree, is assigned a priority 1.

Comment: It is noted that the desert grassland situation that this variety supposedly developed in has not rejuvenated even after 40 or 50 years of protection in the Big Bend National Park with complete rest from grazing, fire, or other disturbances. Could it not be that some level of disturbance is required to create the dynamics on which most grasslands seem to thrive? Perhaps grazing and fire should be tried as a restorative treatment. Why is it automatically assumed that these disturbances are detrimental to these cacti? We seem to always be advocating the same scenario that doesn't work, total rest. Why does this same scenario appear in virtually every recovery plan for every species, even when we know many of these species are disturbance oriented?

Service response: The recovery plan does not assume that this variety developed in a true grassland situation. This is merely one theory that is reported (see the last paragraph of the habitat section and also task 31 and 3141). The plan does not assume that disturbance is detrimental and does not advocate total rest (see task 314, 3142, and 3144). In fact the plan states that the optimal habitat for ***Echinocereus chisoensis*** var. ***chisoensis*** is unclear, that the role of disturbance in maintaining the plant community needs to be evaluated, and that appropriate management treatments need to be identified and management plans developed.

Comment: It is significant that 40 or 50 years of rest apparently has done little to prevent the decline of the variety. If grazing and other disturbances caused the initial decline, why has total rest not reversed or at least stabilized this trend?

Service response: The exact role of grazing or other disturbance in community changes in Big Bend National Park is unclear. However, there is evidence that disturbances such as grazing in arid environments causes changes in the distribution of water, nitrogen, and other needed soil resources. These changes in soil character result in a patchy or heterogenous distribution of resources needed for plant growth in place of the more even distribution that occurred under grasslands, and promotes shrub invasion. The open area between shrubs loses soil fertility due to gaseous emissions and erosion, and the landscape becomes increasingly desertified. Desertification involves a permanent shift to a hotter, drier microclimate that would not be expected to allow the recovery of the original grassland community (Schlesinger **et al.** 1990).

Comment: Community level questions are too vague (Tasks 313,314, 3144). Without very explicit questions that require detailed knowledge of habitat requirements any data gathered could not be properly interpreted. This task should be deferred until after habitat requirements are better understood and more explicit community level questions can be posed.

Service response: While these task headings may be somewhat general, the narrative sections actually specify the initial work needed. Task 313 includes the collection of simple baseline information for populations (species dominance, density, frequency, etc). The Service feels these studies are very important to initiate early-on to provide a basis for evaluating similarities and differences between populations and for evaluating the context of changes that may be detected in monitoring of populations. Likewise, tasks **3141-3144's** directives are specific and simple. They specify evaluating historical information about vegetation, flooding, climate and land use patterns, seeking information that may be useful in interpreting site histories and inferring dynamics that may have influenced present conditions. They also advise recording the incidence of predation, nurse plants, etc., and checking for any correlation between weather patterns and plant developmental stages. These tasks represent important groundwork to be done before formulating specific quantitative studies of optimal habitat and management or treatment options. As this preliminary overview is accomplished, the need for studies examining specific hypotheses will become more clear, and these studies would also be accommodated under these tasks.

Comment: Is it possible the closely related variety ***Echinocereus chisoensis*** var. ***fobeanus*** could be used for comparative studies that would make interpretation of the weaknesses afflicting ***Echinocereus chisoensis*** var. ***chisoensis*** more easily evaluated? Could this closely related variety be used for some horticultural studies, etc. to reduce impacts to existing vulnerable populations?

Service response: Unfortunately the related variety is known only from Mexico, about 400 km south of the Big Bend Region, and plants are not readily available. However, cultivated material of ***Echinocereus chisoensis*** var. ***chisoensis*** is available.

Comment: It is doubtful that a cultivated collection should be the primary approach for preserving a genetically representative sample of the variety. A seed bank would be much more efficient and less expensive. The cultivated collections would better serve for horticultural research, education, and development of horticultural material.

Service response: Note that the plan calls for both a seed bank AND a cultivated collection to meet both of these needs and describes all of these functions. It is unclear at the present time, however, if seeds can be stored successfully. In addition, to maintain a reliable seed bank, periodic germination testing and replenishment may be needed. These tasks can easily be accommodated when the seed bank (likely at a different locality) operates in cooperation with a garden's research and horticultural staff at the site of the cultivated collection. We

have added to the text of task 2.0 to clarify the relative strengths and anticipated function of the seed bank vs. the cultivated collection to avoid any possible misunderstanding.

Comment: It would seem that for most species the importance of genetic diversity in population viability has been over-rated. There are some situations where genetics of populations might be a cause of concern, but in most cases threats are likely to be much more immediate and require ecological and not genetic management.

Service response: The situation with ***Echinocereus chisoensis*** var. ***chisoensis*** has enough characteristics that could cause severe genetic problems threatening viability that the possibility cannot be discounted. At least a preliminary evaluation should be done before it can be concluded this is not a significant threat, especially as a few simple crossing experiments could help determine if there is significant cause for concern. Currently, populations are extremely fragmented, and individuals are very widespread. This is a cause for concern in an outcrosser, as normal pollination scenarios may be disturbed, resulting in significantly less opportunity for maintaining variability. The number of individuals per population in most cases is below 100, which according to recent literature guidelines could well be within the range where genetic drift can present problems for both-short term and long-term survival (Holsinger, in press). It is believed that this condition is not natural and has been caused at least partly by the selective removal of individuals steadily over a long time, which may have its own unique impacts on genetic processes. In the narrative section of task 3212 these characteristics are reiterated and the text expanded to clarify the reasons for concern.

Comment: The recommendation for close collaboration between managers of cultivated collections and workers studying ecology, reproductive biology, etc. is a good one. One aspect of this collaboration does not seem to have been recognized. Not only may field studies suggest cultivation techniques, but the reverse is also true. Cultivation studies may provide new insights into field.conditions and habitat requirements.

Service response: The plan's recommendation for cooperation was meant to cover this sort of two-way synergism. The parenthetic examples of cooperative work were not meant to appear to apply only to the conservation collection. The text has been modified to improve this.

Comment: An assessment of each population's status should be included as a part of the initial site evaluation, including parameters such as recruitment, age/size structure, and

reproductive success. In addition, the monitoring plan should also include data collection in these areas.

Service response: The initial site evaluation is intended to be a qualitative site description noting any obvious, immediate management needs that would help stabilize sites, rather than a more comprehensive evaluation with quantitative, repeatable data collection. There is no doubt that the necessity of measuring and monitoring populations for the named parameters is critical and should begin early on. Quantitative study and analysis of these factors is recommended in task 3211 (investigating demographic characteristics and requirements for stability). It was also intended to have observations in these areas included as part of ongoing monitoring efforts (though perhaps without the same intensity of effort) as a part of the recommended tracking of reproductive success. The narrative text has been expanded to clarify this.

Comment: There is an exhaustive list of tasks included in the plan. While the information sought is laudable, it would represent a long-term, expensive endeavor to achieve this level of understanding. Several approaches seem to be advocated at once. Tasks need to be prioritized and categorized more definitively, perhaps in a more explicit, linear prescription of how to proceed.

and

Comment: It might be a better approach to establish a sequential process, initially concentrating on such characteristics as demographic structure, recruitment, reproductive success, seed production and viability etc. to pinpoint the exact nature of problems at the population level, and work backward from there to factors that would alleviate them.

Service response: The present condition of this variety appears to be caused by a variety of contributing factors rather than any primary cause/effect relationship. There is good reason to believe that habitat changes and illegal collecting have both impacted the variety and that secondarily, genetic viability may have become impaired to the point that it threatens the chances for survival as well. It is very likely that all three of these factors have a significant influence and must be addressed for recovery to be achieved. As noted in the recovery strategy section, the plan recommends a multi-pronged approach initially (rather than a **stepwise** linear process) in order to efficiently evaluate and address these three areas before decline becomes irreversible. To evaluate and address potential problems in each of these areas will undoubtedly require varied and comprehensive studies and activities and can realistically be expected to be a relatively expensive, long-term endeavor. Such an approach will allow several studies to be conducted simultaneously and provide

the flexibility to take advantage of unforeseen funding opportunities and to promote time and cost-effective partnerships to get research done. All of the population level evaluations suggested are included in the plan tasks. As noted above, priorities of tasks are evaluated according to criteria in the Service's Recovery Plan Guidelines and explained on the first page of the implementation schedule. Those tasks necessary to prevent extinction in the immediate future are assigned the highest priority **(1),** followed by those tasks needed to prevent significant decline or negative impacts **(2),** and finally, those tasks needed to complete recovery objectives (3).

Concerns Regarding Investigating the Potential for Reintroduction

Comment: Because the previous extent of this variety is not known (based on the information in the plan) the word **"reintroduction"** is a misnomer as you have used it here. What you propose is to establish new populations and this is an important distinction and should require more justification. Establishment of new populations should be de-emphasized because introduction of a new species into an area could lead to negative impacts on the native species within that habitat.

Service response: Service policy and guidance (Recovery Plan Guidelines) define reintroductions as placing individuals in sites where the species is or was known or believed to occur. Introductions are defined as placement of species outside the historic range. Service policy does not permit introductions unless an exemption is granted by the regional director. On page 7 of the plan it is noted that the variety was formerly more widespread in the Park and was once known from areas west of the Park. During the public comment period for the draft recovery plan Dr. Anderson (Desert Botanical Garden, Phoenix, Arizona), offered further observations that the area of distribution continues to be reduced, and this report was incorporated into the plan. The Service believes the term reintroduction is appropriate in this case. As noted in the Objective and Recovery Criteria section, page 16, establishment of new populations would be considered only within suitable habitat in the natural, historically likely area of distribution of ***Echinocereus chisoensis*** var. ***chisoensis.*** Note also that task 4 calls for more survey work to be completed in advance of reintroduction.

Comment: Efforts should focus on increasing the numbers within existing populations rather than creating new ones.

and

Comment: A reliance on establishment of new populations as a ***recovery*** method could undermine efforts to preserve naturally occurring populations. Even though most current and potential habitat of this variety is protected, such a practice could constitute a dangerous precedent for other recovery efforts. Creation **of** artificial populations might be used as justification for the destruction of naturally occurring populations.

Service response: Given the contraction in range of this variety and the relatively small geographic area it now persists within, reliance on existing populations, even if increased, would not constitute full recovery. Nothing in the prescribed tasks or approach of this recovery plan devalues or de-emphasizes existing populations. The plan calls for their evaluation and restoration as well. Note that throughout the plan the technique is recommended very cautiously, only after survey work, preliminary studies, and a formal evaluation process have indicated that it is indeed necessary, and only if it is determined that it is feasible. Recovery criteria also require that populations considered valid for meeting delisting criteria must have been proven to be reproductively successful over a ten-year monitoring period.

When restoration of existing populations appears sufficient for recovery of a listed entity, the Service would not recommend reintroduction activity. Reintroduction is an expensive, difficult, and time-consuming undertaking, recommended only in cases where it appears to be the only alternative for achieving recovery. However, failing to develop reintroduction techniques that are critically needed for recovery to avoid the possibility of improper use of the technology would be inappropriate.

Comment: Couldn't the several hundred plants cultivated at the Chihuahuan Desert Research Institute (CDRI) be used now to establish new populations? If funds are limited they should go first to research necessary to determine the potential for reintroduction.

Service response: The plants cultivated at CDRI are derived from only a few individuals removed in advance of a highway improvement project. These plants were produced using **cloning** techniques and are genetically identical to the parent stock. To represent the amount of genetic variability present in a normal, viable population of plants, current guidelines (Falk and Holsinger 1991) call for a sample of from 10 to 50 genetically different stock plants from a population, depending on species characteristics. This variety has several characteristics that tend to result in greater population heterogeneity and require a sample on the high end of this range (40 to 50 individuals) to cover needed levels of genetic variation. These factors include fragmented historical populations, a small breeding area, microsite differences in the sites, and the fact that plants are

long-lived perennials. In addition they are outcrossing, most likely have animal-dispersed seed, and possibly occur in some sort of late successional community. The cultivated plants on hand now are derived from so few stock plants they may not have the genetic variability present in a normal population, and we could not expect the new population to be viable and have a good chance for long-term survival. Because of this, the Service feels that planting them out now in attempts at reintroduction would not be using them in the most appropriate manner.

There are additional reasons why it is premature to attempt reintroduction immediately. While numerous reintroductions have been attempted across the country in recent years, very few have been successful, even for a short time. We have learned that even when cultivation of the plants is relatively easy, complex site interactions and management requirements make the restoration or recreation of natural communities extremely difficult. Conservation biologists are reaching a consensus that careful study, design, preparation, data gathering, and a commitment for long-term monitoring and support are needed before reintroduction is attempted (Center for Plant Conservation conference on reintroduction, proceedings in preparation). Before reintroductions begin it is important to have a better understanding of why the current populations are in decline and how to manage populations to prevent this. To establish new populations when we have not yet figured out how to stabilize and maintain the natural populations could waste plants (or seed), time, and money.

For these reasons, the recovery strategy section of the plan calls for protection and stabilization of existing populations and establishment of a genetically representative reserve of plant materials in seed and plants first. This will address the immediate threat of extinction and allow the information gathering and planning necessary to ensure the best chance for success in reintroduction attempts. Habitat studies, management studies, and viability studies are necessary. We need to understand what conditions are necessary for a healthy and viable population before we attempt to establish new populations. When we feel we understand the critical features of habitat, establishment, and maintenance of plants, the plan calls for a new evaluation of the need and potential of reintroduction as a recovery approach (task 5). If it is still felt to be needed, initial small-scale pilot studies are advised to test hypotheses and techniques and evaluate feasibility.

Comment: Reintroduction should be de-emphasized because if factors causing the decline of existing populations are not identified first, new populations may also decline to extinction, and efforts will be wasted.

Service response: See previous response. Note also that in task 5 (Assess restoration feasibility), the recovery plan calls for reintroduction to be attempted cautiously, and only after these questions are addressed.

Comment: Couldn't the CDRI cultivated plants be planted out among the existing populations to bolster them until some of these other questions are answered?

Service response: The Service feels it would be helpful and informative to return a few of the cultivated plants to the same population and general area where they were originally collected, using an experimental context with regular monitoring, quantitative data collection and analysis. The chances of success in transplantation and in revitalizing or restoring this population are greatest. Many studies have shown that individual survivorship and fecundity are greatest when individuals are replanted in their area of origin (Huenneke and Holsinger, **in** press). Using this approach, we would also gain useful information about transplantation techniques and problems. The number of plants that can be used for this purpose, however, should be limited and carefully planned. If too many individuals are returned to the population relative to the number that were originally removed, genetic swamping of the existing population with the cultivated genotypes could occur.

Use of cultivated material from one population to augment any other existing populations should be avoided for now. Great progress has been made recently in the population genetics of rare species, and recent evidence suggests that WITHIN populations there is or may be local genetic adaptation to various microsite characteristics where the habitat varies somewhat (Falk and Holsinger 1991). This internal variation could be extremely important in maintaining a population's ability to persist on a particular site. Further recent work suggests that genetic differentiation BETWEEN populations may be great enough that exchanging individuals between populations lowers average individual viability (Huenneke and Holsinger, **in** press). Because of this, importing plants from outside a population for purposes of augmentation may be detrimental instead of helpful. Other approaches may be more effective. In addition, variation AMONG populations represents a significant portion of the total variability contained in a species and is considered to be of great significance in terms of evolutionary adaptation and long-term viability of a species as a whole (**Falk** and Holsinger 1991). Given this information, as a general rule, maintaining the genetic integrity of existing individual populations is advised unless there is no alternative.

Given our present level of understanding, it seems the best use of the present cultivated material would be to use a limited number in an experimental effort to upgrade the condition of the

population from which they were extracted, gathering as much information as possible that could apply to future transplant efforts as well. Because there is a relatively good supply of these cultivated plants, there is excellent potential to do exhaustive study, if necessary over several trials, to work out these techniques. In addition the plants have great value in providing material for additional experimental work on techniques needed to establish cloned plant material in the wild, breeding systems, response to artificial pollinations, and as source material for educational efforts, horticultural development efforts, etc. Some, of course, should undoubtedly continue to be held in reserve for stock plants that will be needed in future attempts to establish new populations. Learning how to cultivate and produce these plants has given us a good start in attempts to establish a conservation collection.